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THEORY OF SCIENTIFIC PUBLICATION PRODUCTIVITY

10 Russell C. Coile

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A BIBLIOMETRIC EXAMINATION OF THE SQUARE ROOT THEORY  
OF SCIENTIFIC PUBLICATION PRODUCTIVITY

Russell C. Coile

ABSTRACT

A postulated model of scientific productivity asserts that half of all scientific papers in a field are contributed by a few highly productive authors numbering approximately the square root of the total of scientific authors.

Available data has been examined to judge the validity of the theoretical model on the basis of empirical evidence. An analysis has been made of the data collected by pioneer bibliometrician, Alfred J. Lotka, on the frequency distribution of scientific productivity of chemists listed in Chemical Abstracts. The total number of chemists whose names began with letters A or B was 6,891. The 84 most productive chemists, the square root of 6,891, contributed 4,207 papers of the total of 22,839 papers, or 18 percent -- considerably less than the 50 percent asserted by the model.

Additional data concerning the scientific productivity of physicists, mathematicians, biologists, computer scientists, econometricians, operations researchers, and entomologists suggests that the most productive square root of the total authors produced an average of 25 percent of the total papers. These data bases had scores between 9 percent and 38 percent with one exception -

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page

→ a 57 percent recorded for a university physics department. Here the research-oriented bionic men published between four and eight papers per year each, while their teaching-oriented colleagues published fewer papers.

#### INTRODUCTION

In 1963, Price (1), asserted that half of the scientific papers are contributed by the most prolific square root of the total number of scientific authors. He returned to this subject in 1976, stating again (2) that the top  $\sqrt{P}$  authors will produce at least half the total papers published by the population P. No experimental data was presented to validate this theory. However, in a recent paper, Allison (3) stated that the validity can be judged on the basis of empirical evidence. It is the purpose of this paper, therefore, to assemble available bibliometric data on scientific productivity in order to examine this theoretical model. Price's (4) definition that "a scientist is any person who has ever published a scientific paper" will be used in this discussion.

#### EMPIRICAL DATA

Table I presents bibliometric data on scientific productivity for various disciplines. An effort has been made to include all familiar pre-1963 data bases used by Alfred J. Lotka (5), H.A. Simon (6), W. Shockley (7), etc. as well as a number of other data bases. The table contains for each referenced entry, the number of

TABLE 1

PERCENT OF TOTAL PAPERS PRODUCED BY MOST PROLIFIC SQUARE ROOT  
OF THE TOTAL AUTHORS

Data base	Reference	Years of survey period	Total papers	Total authors	Square root of total authors	Papers by square root authors	
						square root authors	total papers
Chemists	(5)	10 yr	22839	6891	84	4207	18‡
Physicists	(5)	10 yr	3396	1325	37	452	13‡
Mathematicians	(6)	25 yr	1124	278	17	427	38‡
Geneticists	(7)	33 yr	3662	826	29	1317	36‡
Entomologists	(8)	1 yr	656	411	21	123	19‡
Mycologists	(8)	1 yr	2229	1527	40	204	9‡
Entomologists	(8)	1 yr	2379	1534	40	234	10‡
Econometricians	(9)	20 yr	1759	721	27	460	26‡
Los Alamos Physicists	(10)	4 yr	258	98	10	64	25‡
Brookhaven Physicists	(10)	4 yr	391	87	10	148	38‡
Columbia U. Physicists	(10)	4 yr	180	18	5	103	57‡
Statisticians	(11)	243 yr	1866	632	26	684	37‡
Lasers	(14)	3 yr	1148	457	22	300	26‡
ORSA	(15)	15 yr	1167	567	24	135	12‡
Information Theory	(16)		188	112	11	53	28‡

total authors, the square root of the total authors, the total papers, and the actual number of papers contributed by the most productive square root of total authors. Finally, the table gives the ratio of actual papers to total papers as a percentage. One can therefore readily compare these percentages to the postulated 50 percent predicted by the model.

For example, Lotka made a classical analysis of the frequency distribution of scientific productivity of chemists listed in Chemical Abstracts, 1907 - 1916, where he counted 6,891 total authors whose names began with letters A or B. The square root of 6,891 is 84. The most productive 84 chemists contributed 4,207 papers of the total of 22,839 papers, or 18 percent. This is considerably less than the predicted 50 percent.

Inspection of the table shows that the different batches of data give results ranging from 9 percent to 38 percent with one exception of 57 percent. The 57 percent came from the Columbia University physics department which had some extremely prolific authors who each published between four and eight papers per year for the four years of Shockley's survey. Some of the other members of the department seem to have devoted more time to teaching and less to research and published fewer papers.

#### CONCLUSION

The overall results suggest that further research on the question of the productivity of the elite seems necessary, since the prolific authors who number the square root of the total authors do not appear to produce half of the papers.

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